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METHOD FOR FABRICATING A SEMICONDUCTOR EPITAXIAL WAFER HAVING DOPED CARBON AND A SEMICONDUCTOR EPITAXIAL WAFER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a semiconductor epitaxial wafer and method for making the same. More particularly, the present invention relates to a method for fabricating a semiconductor epitaxial wafer in which a silicon substrate is doped with carbon by melting chunks of polysilicon and carbon together, thereby effectively controlling interstitial silicon and thereby affecting a device-active region and thus realizing a very large scale integrated semiconductor device.

2. Description of the Prior Art

In general, wafer fabrication processes necessarily require ion implantation steps. The implantation of ions into silicon crystals, however, produces a great quantity of interstitial silicons. Such interstitial silicons cause a transient enhanced diffusion of boron

during subsequent heat treatment steps, and also form a deep trap level within a silicon band gap. Furthermore, transient enhanced diffusion of boron often results in a reverse short channel effect in a short channel transistor, while the deep trap level gives rise to degradation in device characteristics, such as junction leakage current.

As a solution to these problems, prior art technology has used a proximate gettering methods in which carbon is implanted into a channel region to absorb the interstitial silicons. Although proximate gettering methods can advantageously suppress the transient enhanced diffusion of boron by implanted carbon, unfortunately, the carbon atoms may form another trap level causing an increase in junction leakage current.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method for fabricating semiconductor epitaxial wafers that are capable of suppressing an increase in junction leakage current due to a trap level formed by doped carbon.

Another object of the present invention is to provide

a method for fabricating a semiconductor epitaxial wafers that are capable of improving an intrinsic gettering effect by forming many more intrinsic gettering regions.

These and other objects are attained in accordance with the present invention by a method for fabricating a semiconductor epitaxial wafer having doped carbon, the method comprising the steps of providing silicon containing carbon, growing an ingot from the silicon containing carbon, forming a silicon wafer with carbon by slicing the ingot and then surface-treating the sliced ingot, and growing an epitaxial silicon layer on a surface of the silicon wafer with carbon.

According to another aspect of the present invention, a method for fabricating a semiconductor epitaxial wafer having doped carbon, the method comprising the steps of mixing a quantity of carbon with a quantity of silicon and then melting together the quantities of carbon and silicon, growing an ingot from the melted silicon containing carbon, grinding the ingot so as to produce a flat surface and a notch, slicing the ingot into a piece of a silicon wafer having carbon, polishing the silicon wafer having carbon, and growing an epitaxial silicon layer on a surface of the polished silicon wafer having carbon, is provided.

According to another aspect of the present invention, a semiconductor epitaxial wafer, comprises a quantity of carbon contained within a quantity of silicon; an ingot formed from the silicon containing carbon; a silicon wafer having carbon obtained by slicing the ingot to obtain a plurality of rough wafers; and an epitaxial silicon layer formed on a surface of each silicon wafer having carbon.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view showing quantities of polysilicon and carbon together in a crucible to be used in the method steps for fabricating a semiconductor epitaxial wafer according to an embodiment of the present invention.

Fig. 2 is a schematic view of the polysilicon and carbon melted in the crucible in the method for fabricating a semiconductor epitaxial wafer according to an embodiment of the present invention.

Fig. 3 is a schematic view of a silicon ingot having doped carbon being grown by using the Czochralski method in the steps of the method for fabricating a semiconductor epitaxial wafer according to an embodiment of the present invention.

Fig. 4 is a schematic view showing being sliced into a piece of a primitive wafer having doped carbon in the method for fabricating a semiconductor epitaxial wafer according to an embodiment of the present invention.

Fig. 5 is a schematic view showing the steps of polishing the sliced wafer having doped carbon in a method for fabricating a semiconductor epitaxial wafer according to an embodiment of the present invention.

Fig. 6 is an elevational side view showing the step of growing an epitaxial layer on the polished wafer having doped carbon in a method for fabricating a semiconductor epitaxial wafer according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will be now described more fully hereinafter with reference to the accompanying drawings, in which the steps of preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully

convey the scope of the invention to those skilled in the art.

As shown in Fig. 1, a quantity of crystalline silicon 1 is contained in a crucible 10 in preparation of forming a silicon wafer. In addition, a quantity of carbon pieces 3 is mixed in with the crystalline silicon 1 in the crucible 10. The mixed quantities silicon 1 and carbon 3 are then heated until the mixture reaches a liquid silicon state 4, as shown in Fig. 2. Preferably, the doping concentration of carbon in the molten silicon 4 is about 1×10^{14} to 5×10^{17} atoms/cm^3.

Thereafter, referring to Fig. 3, a seed crystal 5 of the required orientation is touched to the upper surface of the molten silicon 4 and then slowly raised upwardly while the seed crystal 5 and the crucible 10 are rotated in opposite directions. A silicon ingot 7 having doped carbon therein is therefore grown to a single crystal structure. Such a crystal growing method is well known, and has been referred to as the Czochralski method. Alternatively, another crystal growing method, such as the Floating Zone method, may be used. Preferably, the oxygen concentration in the ingot 7 is controlled to a level between 8 and 13 parts per million atoms (ppma).

Subsequently, the silicon ingot 7 having doped carbon

and grown in accordance with the specific orientation is subjected to a grinding process in order to produce a flat surface and a notch, and then fastened to a carbon beam by using epoxy. Next, as schematically depicted in Fig. 4, the silicon ingot 7 is sliced into a plurality of pieces, comprising primitive wafers 11 having doped carbon. Then the primitive wafers 11 may be further subjected to an edge grinding process.

Thereafter, referring to Fig. 5, the sliced wafers 11 having doped carbon undergo a surface polishing process by using a polishing apparatus 30. In addition, other conventional processes such as rough polishing, edge polishing, etching in an acid or alkali solution, thermal doner killing, and fine polishing may be further performed before or after the surface polishing process.

Next, the polished wafers, one polished 11 having doped carbon shown in Fig. 6, is supplied to an appropriate chamber (not shown) for epitaxial silicon growth. Referring to Fig. 6, in the chamber, an epitaxial silicon layer 13 is grown to a predetermined thickness on the polished wafer 11, so that a semiconductor epitaxial wafer 15 having doped carbon is obtained. Preferably, the thickness of the epitaxial silicon layer 13 is controlled to a value between 0.5 and 5 microns.

As fully described hereinbefore, the fabrication method according to the present invention has advantages as follows. Since the epitaxial silicon layer on the silicon wafer doped with carbon forms a device active region in subsequent fabrication steps (not further described herein), interstitial silicon in a certain depth is combined with carbon. Accordingly, the concentration of silicon infiltrated into the device active region can be considerably decreased. That is, the present invention provides an effect according to carbon doping in addition to an existing advantage according to the use of the epitaxial silicon wafer. In particular, since the silicon wafer having doped carbon has many more intrinsic gettering regions than other silicon wafers having no doped carbon, the intrinsic gettering effect is also improved.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in, and only being limited by, the following claims.